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Improvements to automatic Tarif

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IMPROVEMENTS TO AUTOMATIC TARIF

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Summary

Automatic Tarif is an equipment which may be used to make frame-by-frame corrections of colour-balance, gain, and lift errors, in the colour-separation output signals of a telecine. This Report describes modifications that have been made to the automatic Tarif equipments in service use so as to make their operation more acceptable on a wider range of subject matter.

The Report also describes an attempt to correct automatically for colour-balance errors in the output signals of an electronic colour camera; a possible application would be to correct hue errors caused by rapid changes in the colour temperature of the scene illuminant. Although it has been found that, for most scenes, colour-balance errors are significantly reduced, the overall standard obtained was below that expected from a correctly aligned camera. The use of fully automatic correction would therefore be confined to situations where it was impossible to realign the camera manually or semi-automatically.

Issued under the authority of

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Section Title Page

Summary .... Title Page

1. Introduction 1

2. The modifications 1

2.1. Colour-balance correction 1
    2.1.1. Instrumentation 1
2.2. Black-level correction 2
    2.2.1. Instrumentation 2

3. Results of field-trial 2

4. Automatic colour correction of electronic camera pictures 3

5. Conclusions 4

6. Acknowledgements 5

7. References 5

IMPROVEMENTS TO AUTOMATIC TARIF
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1. Introduction

Automatic Tarif, which has been described in a previous Report,[1] was designed to correct gamma-corrected telecine signals for exposure and colour-balance errors in film. It measures certain parameters of the signals and applies rules, based on simple statistical properties of television pictures, to effect correction.

Colour-balance errors are removed by equalising the average values of the colour-separation signals (integration-to-grey). Black-level errors and low-light colour casts are removed by equalising the blackest levels of each of the colour separation signals to a pre-set 'black' level. Overall, or master video gain is adjusted so that the largest of the peak values of the three signals just reaches white level.

With these correction rules, automatic Tarif produces improved pictures from film having, for example, faded dyes, incorrect colour balance, or printing disotrtions. The pictures from technically good film tend to be degraded to an unacceptable extent, because not all correctly displayed pictures integrate closely to grey, or contain information near black. These pictures are reproduced with colour or black-level errors, even though they may have originally been perfect. This is referred to as 'subject failure'.

The purpose of the work described in this report was to test modifications to the black-level and colour-balance correction rules, designed to reduce the incidence of subject failure. The modified colour-balance correction was also tested on pictures from an electronic camera, to see if errors caused by illuminant colour-temperature changes could be corrected. Previous attempts, using integration-to-grey, had failed because of the higher minimum standard of colour reproduction obtainable from electronic cameras.

2. The modifications

2.1. Colour-balance correction

The colour-balance correction circuits detect colour casts by measuring and comparing the mean levels of the input colour-separation signals, field by field. Any inequality is taken to indicate an unwanted colour cast. However, this inequality could also be caused by a significant area of saturated colour. Pictures containing a dominant colour are therefore given an incorrect complementary colour shift, and the dominant area becomes desaturated. However, it was suggested* that the reproduction of such scenes could be improved by limiting the saturation of the signals fed to the mean-level detectors. With carefully chosen limits, this should not affect the reproduction of scenes needing correction for reasonably large colour casts, but complete integration-to-grey would be inhibited in the presence of saturated areas of significant size.

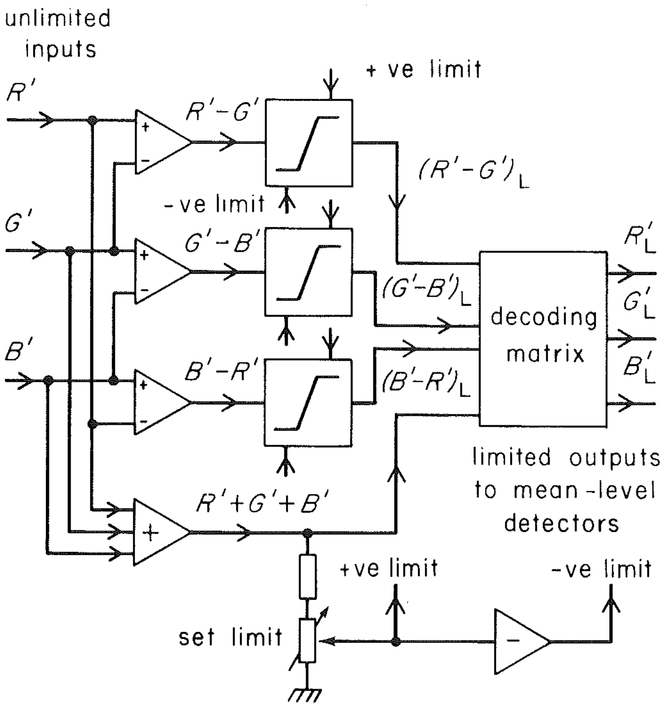

Fig. 1 - Block diagram of colour-saturation limiter

2.1.1. Instrumentation

Automatic Tarif operates on colour-separation signals directly, and it was therefore necessary to convert these into luminance and colour-difference signals in order to limit colour saturation. Fig. 1 shows how this was done. Subtractors and an adder intercept the inputs to the mean-level detectors, and produce difference signals $R'-G'$, $G'-B'$ and $B'-R'$ and a pseudo-luminance signal $R'+G'+B'$. (R', G' and B' denote gamma corrected signals; the subscript L denotes a limited signal.) Saturation is then limited by symmetrically clipping positive and negative excursions of the colour-difference signals. The clipped signals are matrixed with the pseudo-luminance signal to reconvert them into colour-separation signals. At this point the signals have not been corrected for gain or lift errors, and any variation in film exposure causes a corresponding change in signal level. Fixed clipping levels would therefore set an effective limit to colour saturation which varied with film exposure; to prevent this the clipping levels are derived directly from the pseudo-luminance signal.

The measurement circuits form a side-chain and a full video-frequency response is not essential; this made it possible to use integrated-circuit operational amplifiers for most of the functions in the colour saturation limiter, and to produce a compact modification.

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* by G.D. Monteath.

2.2. Black-level correction

Automatic black-level correction fails when a scene intentionally contains no information near black, or when the blackest level changes because of movement. In the first case, picture contrast is increased excessively by the combined action of the black-level and master-gain controls; in the second case, picture brightness fluctuates with movement in the scene. Nevertheless automatic black-level correction is very effective in removing low-light colour casts in films in which the dye layers have faded, or have been developed to different maximum densities. It has been suggested* that low-light colour correction could be retained without introducing black-level errors by equating the three blackest levels to one another rather than to a pre-set reference. Since coloured shadows are usually caused by either one or two of the dyes failing to reach the intended density it was decided that each of the black-levels should be made equal to whichever was originally the lowest.

2.2.1. Instrumentation

Measurement pulses are added to the colour-separation signals, with magnitudes equal to the measured maximum, mean and minimum levels of the signals; they are inserted, during the field-blanking intervals, at the inputs to the processing amplifiers. The offsets and gains of the amplifiers are adjusted during the field-blanking interval so that the video black, mean and peak levels, as indicated by the processed pulses, reach pre-determined reference levels. The pulses are then removed by blanking in the output stage of the equipment.

In order to equalise the black-levels to one another, instead of to a fixed reference, three diodes were used to measure the magnitude of the smallest of the minimum-level pulses. This was substituted for the fixed black-level reference.

3. Results of field-trial

The modifications were fitted to a number of units, located in the Television Centre main telecine area, which were used for film that was difficult to correct manually because of large or quickly varying colour-balance and exposure errors. Such films are often the result of several duplications, perhaps with different film stocks intercut, or are old monochrome films that tend to have rapidly fluctuating brightness and contrast. For the field trials it was arranged so that either of the modifications could be switched in or out at will. Also, two degrees of colour-difference signal limiting were provided, viz ±10% of $R' + G' + B'$, and more severe clipping at ±3·5%. The gamut of the colours that fall within the 10% limit are shown on a C.I.E. (1960) U.C.S. chromaticity diagram in Fig. 2. The standard equipment can provide black-level correction alone, black-level and overall gain, or black-level, colour-balance and overall gain control. In addition, although the overall gain control is usually used to set the peak output signal to white level, two other options exist.

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* by Television Operations and Maintenance Department.

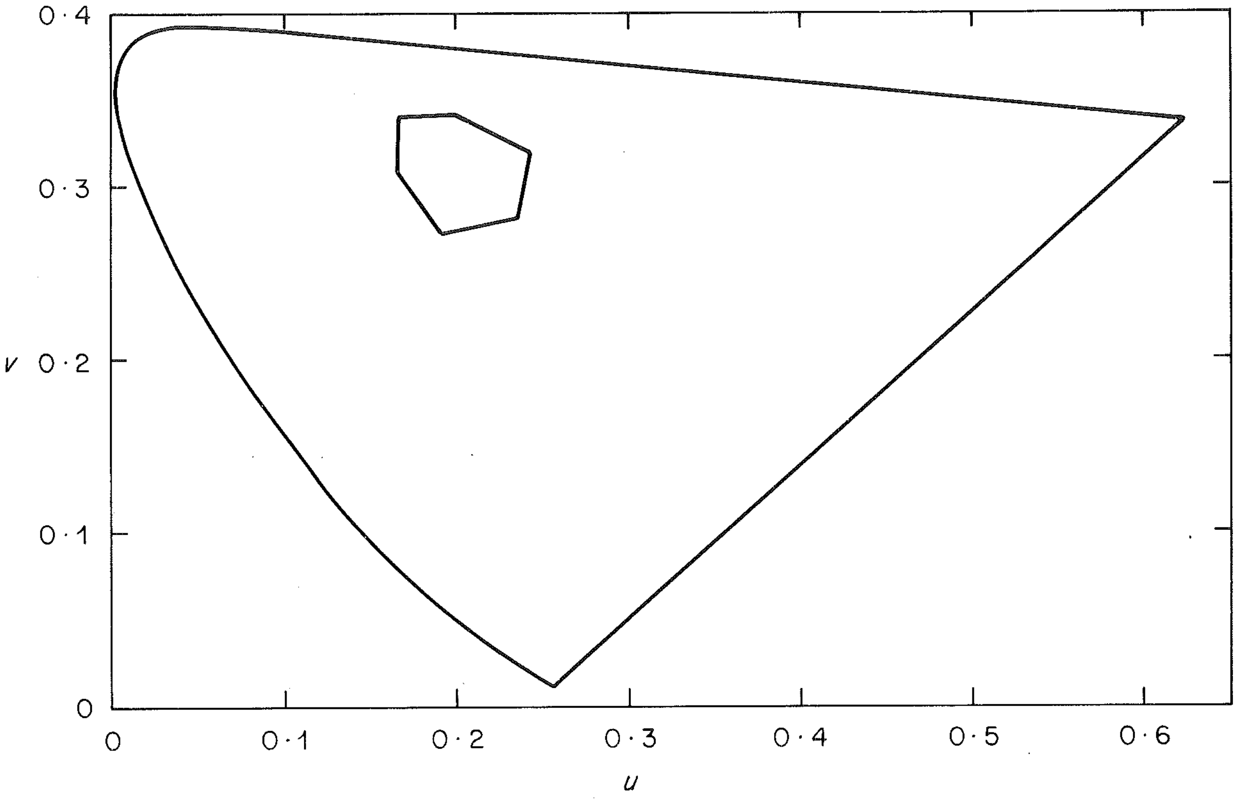

Fig. 2 - Locus of colour limit (10% setting)

For films containing intentional fades to black, or other special effects that cause large luminance changes, it can be arranged that the output peak level follows the input peak level. (This does not necessarily imply unity gain; colour-balance correction may cause the peak level to move from one colour-separation signal to another.) Alternatively, the output peak level may be allowed only to follow relatively high-frequency fluctuations in the input peak level, returning to white level when the input peak level is substantially constant. This option is used to reduce fluctuations during movement, and to prevent momentary drops of gain caused by, for example, flashing lights and intermittent specular reflections.

The new modifications were therefore adding to an already large number of possible control modes, and it was becoming difficult to choose the best mode for any particular film without a thorough rehearsal, thus potentially removing one advantage of using automatic equipment.

For the modifications to be acceptable it was therefore important that they should not make the equipment more difficult to use and so the operational staff were also asked to decide if any of the modes of operation could be removed.

The following is a summary of comments by operational staff.

(a) The modified black-level correction prevents many subject failures that arise from pictures which are intended to have a varying black-level. The operational choice between this and normal black-level correction is relatively easy to make, and both options should be retained.

A problem with automatic Tarif is that non-gain-compensated black-level correction introduces colour-balance errors in scenes that have unequal black-levels in the red, green and blue separation signals. 'Blackest-level' equalisation in general introduces a smaller luminance error than 'black-level to reference' equalisation, and this makes the colour balance error less noticeable.

(b) Limiting before integration-to-grey improves the correction of scenes containing saturated colours, as expected. However, scenes are progressively restored to their original colour balance, which may be in error, as the limiting is increased. It is recommended that, as an overall compromise, 10% limiting be incorporated into the integration-to-grey. The other two modes can be removed; with no limiting the correction is too severe, and limiting to 3·5% leaves too small a correction range so that relatively small colour-casts are not completely removed.

4. Automatic colour correction of electronic camera pictures

To produce pictures without colour errors an electronic camera must be balanced for the scene-illuminant colour-temperature. This is done by adjusting the gains of the camera video channels until equal red, green and blue signals are obtained with the camera focussed on a neutrally reflecting chart. In a studio it is usually a simple matter to align a camera in this way.

An automatic colour-balance corrector might ease some of the difficulties encountered with mixed or natural light. It was known from previous experiments that

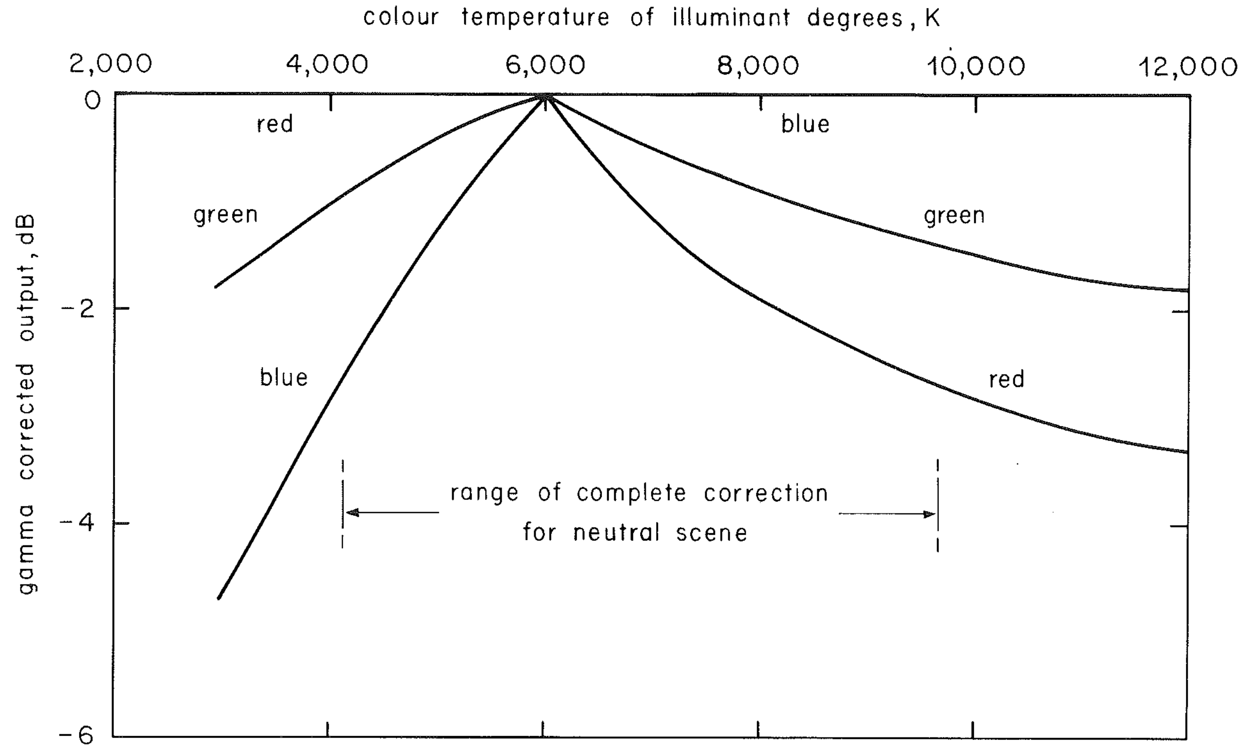

Fig. 3 - Electronic camera: output versus illuminant colour-temperature

integration-to-grey was inadequate for electronic camera pictures. However, it was decided to test such a system again with the modified equipment, since it had shown a definite improvement in performance when used for films.

Calculations were first made to estimate the effective range of correction when using limited integration-to-grey. Fig. 3 shows how the gamma-corrected colour-separation outputs of a camera balanced at 6000°K vary over a range of scene illuminants. The graph shows the outputs from a neutral scene, with the camera iris adjusted to bring the highest signal always to a relative level of 0 dB. The two arrows indicate the illuminant colour temperatures at which the limiters would take effect, using the clipping level of 10% that was found to be the best compromise for telecine pictures. Outside this range a scene containing only neutrals would no longer be completely corrected; colours in the scene would reduce this range, or in the limit cause it to disappear entirely.

Consider a picture containing 39% sky, 24% grass, 35% flesh tone, and a small neutral area. (These proportions were chosen to make the picture integrate exactly to grey.) Typical examples of these colours are shown in Fig. 4 and it can be seen that they lie close to the 10% limit locus. For this reason the effects of even a small change in illuminant would not be removed completely. The colour cast remaining in the neutral area after correction is shown in Fig. 5. It is again assumed that the iris has been adjusted to maintain a peak signal level from the neutral of 0 dB. Comparing this Figure with Figure 3 (no correction) shows that, at any colour temperature, the colour cast has been reduced by approximately 40%.

Several practical tests were then carried out. With a camera balanced for tungsten lighting but used in daylight, the colour cast in scenes containing only small amounts of colour was approximately halved. As expected, the effectiveness of the correction was reduced as the proportion of colour in the scene was increased. With a compromise setting of the camera colour-balance it would have been possible to correct for the colour cast at both temperatures, but in either case colour in the scene would have reduced the correction range.

To induce subject failure, a person walked past a series of coloured drapes; for this test the camera was balanced for the lighting in use. Changes in flesh tone were most noticeable in front of magenta or red drapes, which caused objectionable green and cyan casts.

The quality of the corrected picture was almost invariably worse than that of the original picture. However, gross errors were rare, and, without the original picture for reference, the colour balance arrived at by limited integration-to-grey was usually acceptable.

5. Conclusions

Operational experience with the original automatic Tarif has shown that it can introduce gross errors when scenes do not conform to the basis of its simple correction rules. Two modifications have been made to these rules to improve the colour-balance and black-level control.

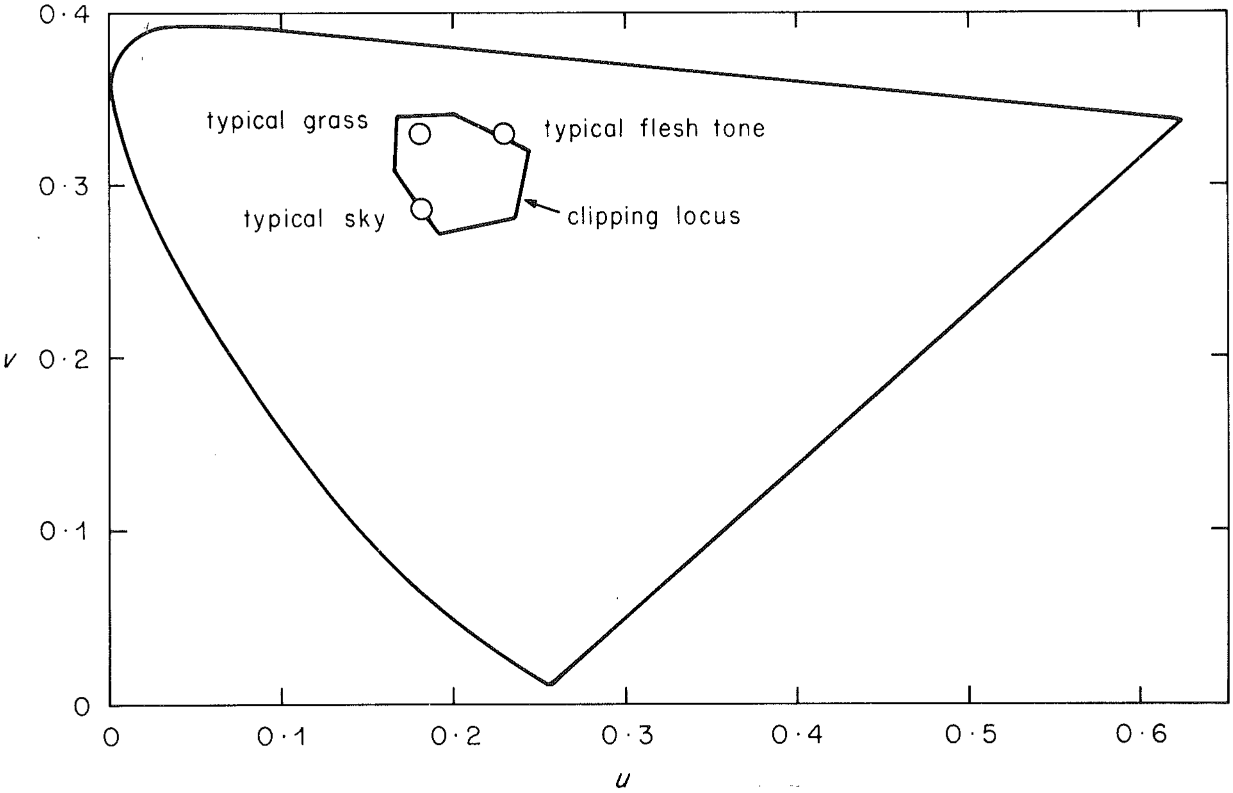

Fig. 4 - Test colours used in theoretical study of electronic camera colour correction

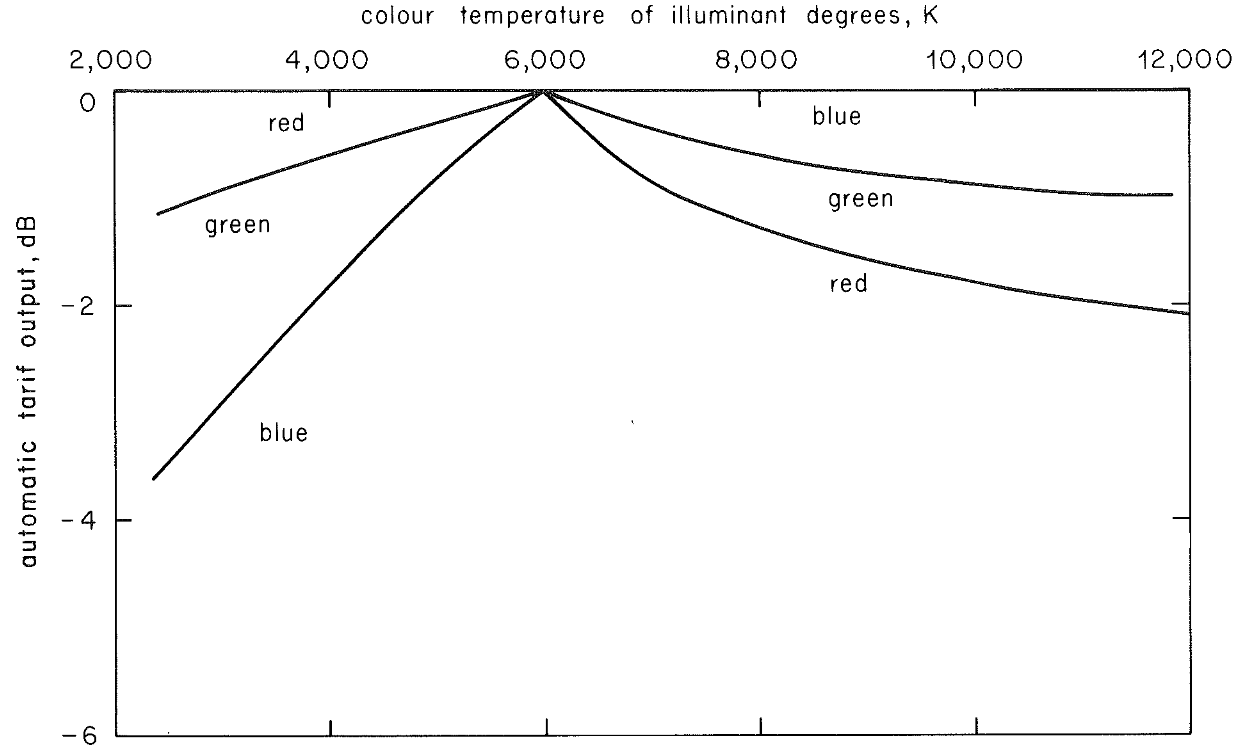

Fig. 5 - Electronic camera: corrected output versus illuminant colour-temperature

The colour-balance control, which corrects errors by integrating all pictures to grey, has been modified to inhibit complete correction in the presence of saturated colours. This reduces the complementary colour shift given to scenes containing a dominant coloured area. A scene with a colour cast is still corrected as before, unless the cast is severe, in which case it is only partially removed. A compromise has been found between insensitivity to saturated colours and sensitivity to colour casts, which gives an overall result better than the previously used complete integration-to-grey.

The black-level control has been modified so that the blackest level in each colour-separation signal can be optionally equated to whichever is the lowest; in the original equipment the blackest levels could only be equated to a fixed reference. This optional form of correction prevents instability on scenes with varying black level, and excessive contrast on scenes with no information near black, while colour casts are still removed from low-light areas. For old monochrome films, in particular, which have rapidly fluctuating black-level errors, the original black-level correction can still be used very effectively. After successful field trials, both modifications have been incorporated in all the automatic Tarif equipments in operational use.

Attempts have been made to use automatic colour-balance control on pictures from electronic colour cameras. Although on most scenes colour-balance errors were reduced, there were some significant subject failures, and the overall standard was below that expected from a correctly aligned camera. The usefulness of automatic correction would appear to be confined to the very few situations in which there are large and rapid changes of illuminant colour temperature and in which it is also impracticable to realign the camera in the normal way.

6. Acknowledgements

The author wishes to thank Mr. P.J. Jones, Television Operations and Maintenance Department, for his comments which appear in Section 4.

7. References

1. WRIGHT, D.T. 1974. An automatic Tarif for news film. BBC Research Department Report No. 1974/15.

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